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Limited Evidence Suggests That Action Observation and Imitation Supports Upper Extremity Motor Rehabilitation in Patients With Stroke

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CLINICAL SCENARIO:
Persons who have sustained a CVA often experience new deficits in motor performance. One focus of occupational therapy for people with stroke is to rehabilitate motor performance skills. Although standard treatment methods have been empirically shown to improve upper extremity motor functioning and are widely applied, many limitations exist. There is a need for the continued development of CVA rehabilitation that will modify or replace standard protocols in order to improve clinical outcomes.

Action observation and imitation is one rehabilitation approach that is gaining attention. Also referred to as modelling or imitation therapy, it consists of the client observing another person performing an action, and then performing or attempting to perform the same action.

FOCUSED CLINICAL QUESTION:
Is there evidence to suggest that action observation and imitation is comparable to standard treatments in the rehabilitation of upper extremity motor skills in persons with CVA?

SUMMARY of Search, 'Best' Evidence' appraised, and Key Findings:
A randomized controlled trial was found (Ertelt et al., 2007) that compared action observation and imitation paired with a standardized stroke therapy protocol, to non-imitative stroke therapy in participants with stroke.

Clinically and statistically significant treatment effects were found for the group engaged in action observation and imitation therapy, while no treatment effects were detected in the control group. In sum, physical training alone did not improve outcomes, but when paired with action observation, it resulted in significant training effects and improved outcomes.

CLINICAL BOTTOM LINE:
At present, there is insufficient evidence to support replacing standard stroke rehabilitation methods with action observation and imitation. However, limited evidence suggests that these methods may support standard CVA treatment protocols and improve outcomes.

Limitations of this CAT:

- The preparer is a relative novice in the subject.
- The literature search was neither complete nor exhaustive.
- This CAT was reviewed by the student's instructor but otherwise is not peer-reviewed.

SEARCH STRATEGY:

Summary of Search:

- Articles referenced in the article "Therapeutic Reflection" in Scientific American Mind were retrieved. Bibliographies of these articles were searched for additional relevant articles, and citing articles were found via CINAHL and google scholar.
- Medline, EbscoHost, CINAHL, Google Scholar, PEDro, and OT Seeker were searched for the terms indicated in the table below. Bibliographies and citing articles were screened for subjective relevance to the PICO question.

Terms used to guide Search Strategy:

- **P**atient/Client Group: Adults post-CVA
- **I**ntervention (or Assessment): Imitation therapy, action observation, mirror neuron therapy
- **C**omparison: CVA/stroke rehabilitation/therapy
- **O**utcome(s): upper extremity motor functioning

Databases and sites searched	Search Terms	Limits used
Medline EbscoHost CINAHL PEDro OT Seeker	Ertelt Buccino Iacoboni Mirror neuron Action observation Imitation Imitation therapy Stroke CVA	Searches were combined.

INCLUSION and EXCLUSION CRITERIA

Inclusion:

- Articles discussing or assessing mirror neuron system functioning in persons with stroke

Exclusion:

- Non-English language articles
- Non CVA conditions

RESULTS OF SEARCH

Five relevant studies were located and categorised as shown in Table 1 (based on Levels of Evidence, Centre for Evidence Based Medicine, 1998 http://www.cebm.net/index.aspx?o=1025)

Table 1: Summary of Study Designs of Articles retrieved

Study Design/ Methodology of Articles Retrieved	Level	Number Located	Authors (Year)
RCT, N=16, follow-up of 7 out of 8 participants in the experimental group only.	2b	1	Ertelt, D., Small, S., Solodkin, A., Dettmers, C., McNamara, A., Binkofski, F., & Buccino, G. (2007).
Case Series: Repeated measures crossover design (N=8), Three measures.	4	1	Celnik, P., Webster, B., Glasser, D.M., & Cohen, L.G. (2008).
Expert opinion based on "first principle"	5	1	Pomeroy, V.M., Clark, C. A., Miller, S. G., Baron, J. C., Markus, H. S., & Tallis, R. C. (2005).
Expert opinion without explicit critical appraisal	5	2	Cattaneo, L., and Rizzolatti, G. (2009).
			Iacoboni, M., & Mazziotta, J. C. (2007).

BEST EVIDENCE

The following RCT was identified as the 'best' evidence and selected for critical appraisal: Ertelt et al., 2007.

Reasons for selecting this study were:

- This study provides the highest level of evidence to address the PICO question
- Comparison of action observation therapy to standard treatment
- Methodology was clarified
- Includes only participants with CVA

SUMMARY OF BEST EVIDENCE

Table 2: Description and appraisal of randomized controlled trial by Ertelt, Small, Solodkin, Dettmers, McNamara, Binkofski, & Buccino (2007).

Aim/Objective of the Study:
To assess whether action imitation can improve motor impairment in chronic stroke patients.

Study Design:
Randomized controlled trial. N=16; two groups (experimental and control).

Frequency of outcomes measurements:

Baseline: 14 days before onset of treatment

Pre-Test: 1 day before onset of treatment, in order to assess stability of motor deficits

Post-Test: at the end of treatment lasting 18 consecutive work-week days

Follow-Up: 8 weeks after the end of treatment in 7/8 participants in the treatment group only

Setting: Outpatient. Further details not specified.

Participants:

N=16

Dropouts: 0

Number available for follow-up: 7 of 8 participants from the experimental group

Diagnosis: CVA of the middle cerebral artery

Eligibility criteria:

Inclusion: Confirmed diagnosis of a single MCA ischemic stroke more than 6 months prior to the study.

Exclusion: Older than 76 years, lesions in the territory of the anterior or posterior cerebral artery, impaired level of consciousness, severe to moderate aphasia, anosognosia or neglect, amnesia or dementia, depression.

Sample type: Convenience sample, recruited from a local rehabilitation center

Key demographics:

N=16, convenience sample recruited from a local rehabilitation center	Experimental group (N=8)		Control group (N=8)		Comparison of groups (probability that the 2 groups represent different distributions) using the Wilcoxon signed rank test.	
	Mean	SD	Mean	SD	Z	Asymptotic significance (two-tailed)
Mean age	57.16	8.73	55.40	10.77	–0.158	0.875
Stroke onset before pre-measurement, in days	1472.9	1258.8	724.8	360.9	–1.47	0.161
Time of former therapies	119.13	57.60	103.63	54.31	–0.630	0.529

Baseline Scores, Experimental vs. control, using Wilcoxon signed ranks test	FAT	WMFT	SIS
Z	–0.435	–0.735	–0.791
Asymptotic significance (two-tailed)	0.663	0.462	0.429

Intervention Investigated

Control:
During sessions of approximately 90 minutes on 18 consecutive work-week days, participants sat with their arms in front of them, motionless as monitored, at a table while watching three 6-minute videos of *geometric symbols* (placebo treatment). After watching each video, they participated in hand and arm actions of increasing complexity as directed by a therapist. The same therapist directed all sessions for both experimental and control groups.

Experimental:
Instead of watching videos of geometric symbols, the experimental group watched videos of a healthy person performing actions – the same actions that they were to perform after the video was stopped. These actions were shown from three different perspectives.

Outcome Measures
All three of the following tests were administered by the same therapist:

Frenchay Arm Test (FAT): This consists of five tasks performed using the affected arm. Items are rated pass-fail, with possible scores ranging from 0/5 to 5/5. Tasks include stabilizing a ruler, drinking from a cup, operating a springed clothespin, handling a cylinder, and combing the back of the head (Heller, 1989).

Wolf Motor Function Test (WMFT): This assessment includes 15 timed UE motor tasks, including 9 functional tasks. Examples of items include placing the hand on a table, lifting a can close to lips, and picking up a paper clip (Wolf et al., 2001). In addition to time, scoring is also based upon a standardized functional ability rating scale. The WMFT has been shown to have "high interrater reliability, internal consistency, and test-retest reliability, and adequate stability when used with chronic hemiplegic subjects" (p. 754, Morris et al., 2001).

Stroke Impact Scale (SIS): This self-report measure assesses 8 domains, including strength, hand function, ADL/IADL, mobility, communication, emotion, memory and thinking, and participation. All domains excluding that of emotion were found to have test-retest reliability, with intraclass correlation coefficients ranging from 0.70 to 0.92 (Duncan, 1999).

Main Findings: Mean scores, SD, Comparisons of pre vs. post, and post vs. fu,

FAT	Pre-test		Post-test		Follow-up		Pre vs. post (Wilcoxon signed rank test)		Post vs. fu (Wilcoxon signed rank test)	
	M	SD	M	SD	M	SD	Z	Asymptotic significance (one-tailed)	Z	Asymptotic significance (two-tailed)
Experimental Group (N =8)	2.625	0.916	4.375	0.518	4.43	0.787	–2.456	0.007	0.000	1
Control Group (N = 8)	2.250	1.035	2.125	0.991	–	–	–1.000	0.1585	–	–

WMFT	Pre-test		Post-test		Follow-up		Pre vs. post (Wilcoxon signed rank test)		Post vs. fu (Wilcoxon signed rank test)	
	M	SD	M	SD	M	SD	Z	Asymptotic significance (one-tailed)	Z	Asymptotic significance (two-tailed)
Experimental Group	10.88	8.308	7.041	6.856	9.320	10.22	2.380	0.0085	–1.859	0.63
Control Group	16.67	14.99	16.97	15.94	–	–	–0.560	0.2875	–	–

SIS	Pre-test		Post-test		Follow-up		Pre vs. post (Wilcoxon signed rank test)		Post vs. fu (Wilcoxon signed rank test)	
	M	SD	M	SD	M	SD	Z	Asymptotic significance (one-tailed)	Z	Asymptotic significance (two-tailed)
Experimental Group	261.9	18.4	277.4	17.0	277.8	17.77	–0.243	0.0125	–0.344	0.731
Control Group	254.6	22.69	252.5	25.33	–	–	–1.124	0.1305	–	–

Effect size for treatment vs. control	FAT	WMFT	SIS
Effect-size r	0.818	–0.375	0.500
Effect size - nominal	large	med	large
Cohen's d	2.846	–0.809	1.154

Original Authors' Conclusions

"…Action observation in combination with previous training schemes has a significant neurorehabilitative impact beyond that of these [training] schemes alone" (Ertelt 2009, p T170). In summary, the original authors conclude that their results are valid, and that action observation and imitation "provides a significant improvement of motor functions […] in chronic stroke patients with a well established motor impairment of the upper limb" (Ertelt 2009, p T170).

Critical Appraisal:

The authors of this study established that the experimental and control groups were not statistically different at baseline. They also established that participants' disabilities were stable by comparing baseline with pre-test scores. The treatments were controlled, with the selection of an appropriate placebo as explained by the authors, and the administration of the universal treatment by the same therapist. The experimental treatment was designed in such a way that uncertainties regarding the mirror neuron system, specifically the perspective from which actions are observed, would be

minimized. Authors attempted to avoid contamination by asking participants to refrain from starting new therapies during the study.

The authors used three outcomes measures, which improves the validity of this study. Each assessment used has strengths and weaknesses, not discussed by the authors. The FAT is functionally-based, but also has considerable floor and ceiling effects. Moreover, the scoring is solely based on whether or not the participant completes an action, but provides no further means for reporting details. The WMFT is also functionally based and allows for the reporting of details regarding quality of movement. The SIS is based on subjective experience, but also correlates highly with objective measures, and so provides results that reflect tangible experience on the part of participants.

The PEDro scale is used to quantify validity indicators for randomized controlled trials. More information about this scale is available through the PEDro website at http://www.pedro.org.au/ . The PEDro scoring for the study by Ertelt et al. is outlined in the table below. Results show that this study satisfies eight of the 11 validity indicators.

PEDro score: 8/11

Criterion	Yes/No	Points
1. eligibility criteria were specified	Yes	1
2. subjects were randomly assigned to groups	Yes	1
3. allocation was concealed	Yes	1
4. the groups were similar at baseline regarding the most important prognostic indicators	Yes	1
5. there was blinding of all subjects	No	0
6. there was blinding of all therapists who administered the therapy	No	0
7. there was blinding of all assessors who measured at least one key outcome	No	0
8. measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	Yes	1
9. all subjects for whom outcome measures were available received 1the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by “intention to treat”	Yes	1
10. the results of between-group statistical comparisons are reported for at least one key outcome	Yes	1
11. the study provides both point measures and measures of variability for at least one key outcome	Yes	1
Total		8/11

Interpretation of Results

Both statistical and clinical significance were achieved in this study. Statistically, the treatment effects of action observation therapy were large enough to be detected on three outcomes measures, including the FAT, WMFT, and SIS, all of which are valid and reliable indicators of treatment effects.

Clinical significance of these results warrant examination according to each of the outcomes measures:

The FAT scores increased for the experimental group by an average of 1.75 points. In applied terms, the experimental group was able to perform 2.63 out of 5 tasks at pre-test, and 4.38 out of 5 tasks at post test. This compares to no change for the control group. The ability to perform FAT tasks is clinically significant. The most dramatic examples are combing the back of the head and drinking from a cup. Regaining the ability to perform such tasks has a tangible effect on one's daily routine.

The WMFT scores for the experimental group improved by an average of -3.839, which indicates that this group decreased the time it took for them to perform the 15 test items by almost four seconds, from 10.88 to 7.041. In other words, the experimental group performed the tasks after treatment in 65% of the time it took them to perform the same tasks before treatment. This compares to no change for the control group. Increasing the speed with which motor actions are executed is clinically significant, as it can lead to greater satisfaction, reduced frustration, greater feelings of self-efficacy, and greater efficiency.

The SIS scores for the experimental group improved by an average of 15.5 points, from 261.9 to 277.4. Each point increase indicates an improvement by one point on a 5-point likert scale. This compares to no change for the control group. This improvement in scores indicates that the participants perceived a marked change in the extent to which their CVA was impacting their lives.

Summary/Conclusion:
This randomized controlled trial indicates the importance of action observation and imitation as part of a successful post-CVA motor rehabilitation program. The utilization of action observation and imitation made the difference in producing detectable treatment effects, and this in persons whose strokes occurred at least 6 months prior to treatment. Exclusion of action observation and imitation from the motor rehabilitation program rendered the program ineffective, while its inclusion produced significant treatment effects.

Table: Characteristics of included studies

	Study 1 (Ertelt 2007)	**Study 2 (Celnik 2008)**
Intervention investigated	Watching 6-min videos of UE actions before attempting the same actions as directed by a therapist.	Physical training of thumb movements paired with observance of congruent actions.
Comparison intervention	Watching 6-min videos of geometric symbols before attempting therapist-directed UE actions.	Physical training of thumb while observing non-congruent actions or no actions.

Outcomes used	FAT WMFT SIS	Motor evoked potentials in the extensor and flexor pollicis brevis muscles via transcranial magnetic stimulation.
Findings	Significant differences between the treatment and control groups were found for all three outcomes. The experimental group scored higher than the control group in all measures, and the effects lasted for at least eight weeks.	Statistically significant treatment effects were detected. The corticomotor excitability of muscles used in the observed actions increased in the participants.

IMPLICATIONS FOR PRACTICE, EDUCATION and FUTURE RESEARCH

Although action observation and imitation alone has not been established as a treatment approach, the importance of physical demonstration in motor rehabilitation programs is becoming clear: the inclusion of physical demonstration in motor rehabilitation programs for certain populations produces significant treatment effects.

Practice implications of the study by Ertelt et al. are that occupational and physical therapists should use physical demonstration of desired actions to improve clinical rehabilitation outcomes.

Although it is not clear why physical demonstration results in such significant improvements in motor rehabilitative training effects, researchers suspect that when physical demonstration activates the mirror neuron system, this primes the brain for motor execution (Iacoboni & Mazziotta, 2007). Further research into the properties of the mirror neuron system is ongoing. In addition, research into methods for maximizing treatment effects through physical demonstration has potential for immediate clinical applications. Laboratory scientists and clinicians alike should strive to learn more about the effects of physical demonstration on training.

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